Project report 2020

CombAmmOpt

Elucidation of fundamental COMBustion characteristics of AMMOnia blended fuels to develop and OPTimize the design of low carbon gas turbines for power plants

MAIN PARTICIPANTS

			
Hideaki KOBAYASHI[a]	**Dany ESCUDIE[b]**	**Cedric GALIZZI[b]**	**Sophie COLSON[a]**

[a] *IFS, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai, 980-8577, Japan*
[b] *CETHIL, Bâtiment Sadi-Carnot, 9, rue de la Physique, Campus LyonTech La Doua, 69621 Villeurbanne cedex, France*

Contact: kobayashi@ifs.tohoku.ac.jp, dany.escudie@insa-lyon.fr, cedric.galizzi@insa-lyon.fr, colson.sophie@tohoku.ac.jp

OVERVIEW

Starting year: 2017 **Current researchers** (permanent/non-permanent): 4 person-month/year

Positioning *(Multiple selection allowed – total 100%)*	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design			
Surfaces and interfaces		40%	
Simulation and modeling		60%	

Other: Environment

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

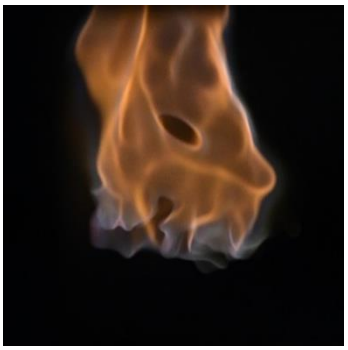
- IFS/2018-2019/Priority Collaborative Research Project
- IFS/2020/LyC Collaborative Research Project
- JSPS/2020-2022/Grant-in-Aid for Scientific Research (B)

Estimated annual budget: 4,000,000 JPY

Highlights & Outstanding achievements

- Ammonia/methane combustion chemistry was investigated for large ammonia content in the fuel, highlighting the main process of production and consumption of NO as well as the interactions between the two fuels.
- Extinction stretch rate was obtained for both premixed and non-premixed ammonia/methane flames, and existing kinetic modeling evaluated based on those experimental results, and way of improvement suggested.
- The stabilization domain of ammonia/methane jet flames was characterized, highlighting some specific behavior under the combined effect of air coflow velocity and ammonia content.
- Interaction flame-burner were clarified showing the evolution of the aero-thermo-chemical coupling occurring at the burner rim when gradually introducing ammonia in the flame.
- Results of this work were published in two papers in an international journal (Combustion Science and Technology).

Illustration



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

The study of low-carbon fuels, such as ammonia, is essential in the context of global warming. However, its combustion is challenging, particularly regarding flame stabilization and NOx emission. One solution to overcome the stabilization issues is to use a mixture of ammonia with another fuel. The aim of this work is the analysis of the fundamental combustion characteristics of an ammonia-methane mixture, which remains merely investigated in the literature. The objective is to understand the kinetic mechanisms leading to the formation of pollutants and the mechanisms controlling stabilization. This work thus focuses on the combustion chemistry of these mixtures, flame fundamental properties experimental characterization, detailed chemistry mechanisms evaluation as well as the detailed study of flame stabilization and flame burner interaction.

Key scientific question (2 lines max; Calibri 11)

What are the key processes leading to NOx production in ammonia/methane flames?
How is flame stabilization affected by ammonia introduction in fuel mixture?

Research method (8 lines max; Calibri 11)

The research method combines experiment and numerical simulation on ammonia/methane flame. Observation of fundamental flame properties (extinction stretch rate, radical and intermediate species profiles) was done by combining experiments (PIV, PLIF) and numerical simulations. The flame chemistry analysis involves the use of numerical simulations to perform reaction path analysis, heat release rate analysis… The flame stabilization study corresponded to global parameter observation in a first stage, combined to shadowgraph imaging measurements, CH* chemiluminescence imaging to track the flame tip as well as temperature measurements to characterize the transition between each regime as well as the flame-burner interactions.

Research students involved *(gray color for previous years)*

Ph.D. candidates (years, institution):

- Sophie COLSON (2017-2020, DD INSA Lyon - TU)

Master/Bachelor students (years):

-

Visits and stays *(gray color for previous years)*

FR to JP (date, duration):

- Dany ESCUDIE (August 2018, 1 week)
- Cedric GALIZZI (August 2018, 1 week)

JP to FR (date, duration):

- Sophie COLSON (January 2020, 1 month)
- Hideaki KOBAYASHI (December 2018, 1 week)
- Sophie COLSON (October 2018 – September 2019, 1 year)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Colson, S., Hirano, Y., Hayakawa, A., Kudo, T., Kobayashi, H., Galizzi, C., & Escudié, D.	Experimental and Numerical Study of NH3/CH4 Counterflow Premixed and Non-premixed Flames for Various NH3 Mixing Ratios.	Combustion Science and Technology	In press.	In press.	2020	https://doi.org/10.1080/00102202.2020.1763326
2	Colson, S., Kuhni, M., Galizzi, C., Escudié, D., & Kobayashi, H.	Study of the Combined Effect of Ammonia Addition and Air Coflow Velocity on a Non-premixed Methane Jet Flame Stabilization.	Combustion Science and Technology	In press.	In press.	2020	https://doi.org/10.1080/00102202.2020.1830276

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Colson, S., Kuhni, M., Galizzi, C., Escudie, D., Kobayashi, H.	Effect of Ammonia Addition on a Non-premixed Methane Jet Flame Expanding in an Air Coflow	58th Japanese Symposium on Combustion	2-4 Dec., 2020	online	Japan	Oral presentation Paper ID 189q (Presentation C312)
2	Colson, S., Kuhni, M., Galizzi, C., Escudie, D., Kobayashi, H.	Study of the Effect of Ammonia Addition on the Stabilization of a Non-premixed Methane Jet Flame in an Air Coflow	International Conference on Fluid Dynamics ICFD2020	28-30 Oct., 2020	Sendai (online)	Japan	Oral presentation Paper ID5287-1 (Presentation OS20-11)
3	Colson, S., Hirano, Y., Hayakawa, A., Kudo, T., Kobayashi, H., Escudie, D., Galizzi, C.	*Experimental analysis and 1D modeling of counterflow ammonia-methane flames*	9th European Combustion Meeting	14-17 Apr., 2019	Lisboa	Portugal	Poster Presentation (Poster No. S1_All_18)
4	Colson, S., Hirano, Y., Kudo, T., Hayakawa, A., Kobayashi, H., Escudie, D., Galizzi, C.	*Investigation of methane-ammonia chemistry from premixed and diffusion flame structures using a counterflow configuration*	37th International Symposium on Combustion	29 July – 3rd Aug., 2018	Dublin	Ireland	Poster Presentation Poster 16339 (2P151)

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				
2				

Others *(gray color for previous years)*

	People	Event	Description	Date
1	S. COLSON	TU – KAUST online meeting	Oral presentation	3th Sept. 2020
2	S. COLSON	CETHIL PhDay	Oral presentation	March 14th 2019
3	S. COLSON	French Combustion Doctor Student Day (Journee Lacas)	Oral presentation	Jan. 22th, 2019